Western Aeronautical Test Range Real-Time Graphics Software Package MAGIC

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WESTERN AERONAUTICAL TEST RANGE
REAL-TIME GRAPHICS SOFTWARE PACKAGE
MAGIC

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Abstract

The master graphics interactive console (MAGIC) software package used on the Western Aeronautical Test Range (WATR) of the NASA Ames Research Center is described in this paper. MAGIC is a resident real-time research tool available to flight researchers-scientists in the NASA mission control centers of the WATR at the Dryden Flight Research Facility at Edwards, California. The hardware configuration and capabilities of the real-time software package are also discussed.

Nomenclature

AFTI	advanced fighter technology integration
ARC	Ames Research Center
CPU	central processing unit
CVT	current values table
DFRF	Dryden Flight Research Facility
FSW	forward-swept wing
IRIS	interactive raster imaging system
MAGIC	master graphics interactive console
MAW	mission adaptive wing
MB	megabytes
MCC	mission control center
NASA	National Aeronautics and Space Administration
PCM	pulse code modulation
RGB	red-green-blue
TRAPS	telemetry-radar acquisition and processing system
WATR	Western Aeronautical Test Range

Introduction

The master graphic interactive console (MAGIC) software package provides a general purpose real-time graphics display system for real-time and post real-time data analysis, in today's mission control center (MCC) at Dryden Flight Research Facility (DFRF)(Fig. 1).

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MAGIC is written in the C language and intended for use on a Silicon Graphics, Inc. (Mountain View, California) interactive raster imaging system (IRIS) workstation equipped with the Unix operating system, level V. It allows today's flight researchers-scientists to create their own displays during preflight, real-time, and postflight checks, based on individual requirements.

MAGIC uses the Gould (Gould Electronics, Inc., Cleveland, Ohio) Ethernet link to pass sampled real-time data between the Western Aeronautical Test Range (WATR) telemetry-radar acquisition and processing system (TRAPS) to an IRIS 3030 workstation.

MAGIC allows the flight researcher-scientist to use interactively the software package capabilities on the rack-mounted workstations in a mission control environment. Figure 2 shows the IRIS workstation in the WATR mission control center at Edwards, California.

The IRIS workstation capabilities include a high-resolution color display. The color display is a 1024 by 768 pixel screen that allows for 4096 color options available to each workstation. The workstation is equipped with a color monitor, keyboard, color hardcopy unit, and mouse for each flight researcher-scientist.

MAGIC provides four major types of information displays: (1) time histories from a real-time data base, (2) X and Y plotting from a frame of real-time data, (3) digital display of discrete or logical parameters from a frame of real-time data, and messages and data written to the IRIS textports, and (4) the capability of displaying predicted data from the research vehicle in real-time applications.

What Is MAGIC?

MAGIC is an interactive graphics package that allows flight researchers-scientists of the MCCs a state-of-the-art display for their flight test operations. MAGIC receives flight data from the aircraft radar signal and sends it to the WATR telemetry-radar acquisition and processing system (TRAPS) in the NASA WATR computer centers. The flight data is stored at the TRAPS in shared memory and passed to the MCCs

the TRAPS in shared memory and passed to the MCCs via an Ethernet link and displayed on an IRIS workstation. Figure 3 shows the flow of the flight data from the aircraft through the various resources with display on the IRIS workstation in the MCC.

The MAGIC Challenge

The flight researchers–scientists assigned to the WATR team required the maximum capabilities of displaying their real-time data within a minimum amount of time. Due to the increasing complexity and challenges of modern research aircraft, demands are growing for real-time graphic displays. The demand for graphics displays also put a strain on the existing Gould TRAPS, therefore, WATR began to look at offloading some of the work onto an intelligent graphic workstation. This offloading was handled with several independent IRIS workstations in the MCCs receiving flight data from one TRAPS. Each independent IRIS workstation can plot a different MAGIC display as well as allow the flight researcher–scientist the flexibility to modify interactively any of the displays during real-time processing or to change to a new display. Figure 4 shows a MCC flight researcher–scientist at an IRIS workstation; also shown are four independent displays in the MCC.

Hardware Configuration

TRAPS

The TRAPS used by flight researchers–scientists of the WATR mission control centers are two Gould 67/80 computers, a Gould 55, and four Silicon Graphics, Inc., IRIS workstations. Figure 5 shows the TRAPS used today and the flow of data received from the research aircraft through the system.

Real-time data are transmitted through the pulse code modulation (PCM) stream sent by the research aircraft to the radar facility and then passed to the front end of the Gould 55. The Gould 55 sends the real-time data to one of the Gould 67/80s, designated as the engineering units converter processor. The real-time data are placed in a current values table (CVT) in a shared memory partition on the Gould. Data are extracted from the CVT and distributed over the Ethernet link to the IRIS workstation by a FORTRAN 77 program running on the second Gould 67/80.

Ethernet Link

The Ethernet link is the critical path for offloading the Gould computers from the graphics requirements onto the IRIS workstations. The Ethernet connection is basically a coaxial cable with several receivers attached to a drop cable connected to a processor. The processors, in relation to the TRAPS, are the Gould 67/80 and the four IRIS workstations. The Ethernet link allows 1 megabit per sec to be transmitted from processor to processor. The Gould passes data to the IRIS workstation and receives commands from the IRIS.

IRIS Workstation

The Silicon Graphics, Inc., IRIS 3030 workstation was selected by the WATR as the package that would best complement the flight researcher–scientist environment in the MCCs. The chassis accommodates up to 16 megabytes (MB) of the central processing unit (CPU), with 32-bit planes of display and a 170-MB Winchester disk (Winchester Electronics, Inc., Watertown, Connecticut). The IRIS 3030 is capable of displaying up to 4096 colors simultaneously, double buffered, from a palette of 6.7 million. Included with the IRIS 3030 is a 19 in. 60 Hz noninterlaced color monitor featuring tilt and swivel, keyboard, and an optical mouse. The color monitor allows the flight researcher–scientist a viewable 1023/768 resolution.

Attached to the IRIS 3030 workstations is a Seiko CH-5300 color hardcopier (Seiko Instruments, Inc., Torrance, California). The unit produces color copies of an image generated from the graphics display terminal at the IRIS workstation. The CH-5300 accepts red-green-blue (RGB) video data to produce clear, vivid prints using thermal transfer technology. From 1 to 99 copies are produced on either a plain paper or a clear polyester film (usable for viewgraphs), thus allowing the researcher–scientist to attend a postflight brief with a color copy of the research data in hand.

MAGIC Display Capability

At the present time, MAGIC allows the flight researcher–scientist the capability of handling 10 pages of setups. The 10 pages are at the discretion of each flight researcher–scientist, as to the various requirements for display. Within each of these pages are the following constraints: (1) maximum of 16 graphs, (2) maximum of 64 plots, (3) maximum of 64 parameters, (4) maximum of 64 digital parameters, and (5) maximum of 80 polygons per page.

Graphs

Each graph displayed on a page is independent of all other graphs on the page. A graph is built to the specifications for that particular illustration. This allows the flight researcher–scientist to specify the limits of the X-axis bottom, X-axis top, Y-axis left and Y-axis right. Each axis requires a minimum value and a maximum value and the division required between the minimum and the maximum limit. Figure 6(a) shows a basic graph setup with the X-axis top and bottom set from 0 to 5, with intermediate grid lines incremented by 1. The Y axis for both left and right are set from a

minimum of -5 to a maximum of 5, with intermediate grid lines incremented by 2.5. The flight researcher-scientist may select any color for the grid lines on the graph.

Plots

A graph that contains an x parameter and a y parameter is considered to be one plot. Figure 6(b) shows one plot assigned to the graph. The x-parameter data value and the y-parameter data value will be plotted according to the limits assigned to this graph. A graph must contain at least one plot and may contain a maximum of 16 plots per page on that one graph. However, it is inconceivable that this would benefit any display.

Parameters

Parameters as defined by the flight researcher-scientist for the MCCs are the various flight parameters to be monitored during preflight, real-time, or postflight processing. As stated previously, an x and a y parameter assigned to a graph is considered one plot. The x parameter is assigned a color that associates it as the current data value of the x and y plot. The y parameter can be assigned the same color or a different color which will plot the prior data value. The x and y parameters, as one plot, will also be assigned a symbol to be determined by the flight researcher-scientist. This symbol will be plotted on the graph first as the current data value, and when a new data value is processed the symbol color will change to the prior data value, and the current value will then be plotted. Figure 6(c) shows that the x parameter associated with this plot is IRADX and is assigned the color "white." The y parameter is IRADY and is assigned the color "yellow." The symbol assigned to this plot is the circle. Note: as the data value is plotted, the old data value changes from white to yellow.

Digitals

Digitals are flight parameters that a flight researcher-scientist defines as wanting to track in their numerical state. The digital parameters may be placed anywhere on the screen and their data processed as a real, integer, or logical value. If the digital parameter is a real value, then the amount of precision can be determined and assigned to that digital parameter. Figure 6(d) shows page 2 of a MAGIC display using digital parameters. The first digital parameter (at the left of the page) is displayed as a real number with a precision of 1. The second digital parameter is displayed as a real number with a precision of 3.

Polygons

A flight researcher-scientist may wish to predict a limit within a graph that is to be assigned to a plot through a polygon displayed within the graph. The size of the polygon and the number of points within the polygon are at the discretion of the flight researcher-

scientist. The constraints for polygons are five polygons to any one graph and 2 to 25 points to build the polygon. Figure 6(e) shows page 3 of a MAGIC setup file with two polygons. Polygon number 1 is a four-point polygon in the shape of a rectangle. Polygon number 2 is a three-point polygon in the shape of a triangle.

Setup Procedures For MAGIC Display

The flight researchers-scientists in the MCCs at Ames-Dryden use MAGIC in their flight test operations. Resident on each IRIS workstation is the (1) MAGIC, the executable code; (2) planecode.set, the setup file (planecode is a four-character plane identification code); and (3) colornum.set, the file which contains all of the color requirements for this planecode.

MAGIC is used by the flight researcher-scientist through various menu options for either the information setup functions or the real-time processing. The menu options are discussed within their appropriate sections.

MAGIC is activated for setup purposes by the flight researcher-scientist at an IRIS workstation. A planecode name must be supplied by the flight researcher-scientist as well as a flight number. The planecode file may or may not be already resident on the system. For the purpose of this discussion, we will use the planecode A111 and assume that this is a new setup for this plane. The flight number is used for display only. Therefore, we will use 202. Figure 7(a) shows the activation of MAGIC at the IRIS prompt, MAGIC's request for planecode, and flight number.

Page 1 of the MAGIC display has been illustrated by figure 7(b) showing four graphs. Graph number 1 illustrates a time history setup. Graph number 2 illustrates a crossplot. Graph number 3 illustrates two crossplots. Graph number 4 illustrates another crossplot with the x parameter having a label to the right of the flight parameter. A label may be added, deleted, or replaced on any of the x or y parameters on a graph. Page 1 is a typical MAGIC display using four graphs with five separate plots. The size and position of all the graphs are at the discretion of the flight researcher-scientist through the menu options provided.

Page 1 of the MAGIC display has been modified to present digital parameters, as shown in Figure 7(c). As stated previously, these digitals may be integer, real or logical in form. The digital parameters may be placed anywhere on the screen the flight researcher-scientist chooses. The digitals may be turned off at anytime if their data display is not required. The flight researcher-scientist may add, delete, or replace any parameter on this list through the menu options provided.

3

Page 1 has once again been modified by adding a polygon to the third graph, as shown on Figure 7(d). The polygon is requested with four polygon points that the flight researcher–scientist has determined to be a critical predicted data envelope. The polygon itself can be deleted or replaced, and another polygon can be added to the graph. The existing polygon can also have points added, deleted, or replaced, all at the discretion of the flight researcher–scientist, through the menu options provided.

Current MAGIC Displays

X-29 Forward-Swept Wing Experimental Aircraft

Figures 8(a) and 8(b) illustrate two X-29 flight displays currently being used in the MCCs by the flight researcher–scientist. The X-29 is an experimental aircraft with several innovations which complicate testing because the effects of each cannot be isolated and dealt with on an individual basis. Some of the more important and interrelated innovations are as follows:

1. Forward-swept wing — requires monitoring and analysis of the wing structure. It is a carbon filament composite structure with greater strength at predicted stress areas.

2. Close-coupled canards — requires monitoring of the canard structures and the forces acting on them.

3. Unstable aerodynamic configuration — requires constant calculations of center-of-gravity location, control surface motion, and aircraft response to pilot inputs. For example, incremental data points are collected to facilitate generating plots of aircraft flying requirements.

4. Fly-by-wire — use of redundant computers to link the pilot's controls to the aircraft control surfaces. Requires monitoring of system functions as well as system health.

The Figure 8(a) display monitors flight loads during testing of a series of envelope expansions. The display uses four graphs with four separate x - y plots and two polygons per graph, for the predicted data envelopes of these loads. Various relative digital parameters are displayed to the left of the graphs.

The Figure 8(b) display monitors the loads against time. This display illustrates four graphs, four parameters plotted against time, plus a digital display.

AFTI/F-111 Mission Adaptive Wing Experimental Aircraft

Figures 8(c) and 8(d) illustrate two AFTI/F-111 displays currently being used in the MCCs by the flight researcher–scientist. The mission adaptive wing (MAW) system consists of variable camber leading and trailing edge flaps, flap actuation mechanisms, and redundant computers and hydraulic systems to control flap position.

The Figure 8(c) display monitors the flight loads during the testing of a series of envelope expansions. For the predicted data envelopes, this display uses four graphs, five plots, two polygons, and ten parameters along with a digital output.

The Figure 8(d) display monitors digital parameters relative to the flight loads being tested to ensure flight safety.

Conclusion

The introduction of MAGIC to the world of the flight researcher–scientist has created a state of the art real-time interactive display system. MAGIC has allowed the flight researcher–scientist a high degree of flexibility during flight test operations. The potential for one TRAPS to supply several IRIS workstations using various MAGIC displays has greatly enhanced the monitoring of flight test programs at NASA Ames-Dryden.

EC82-20642

Fig. 1 Western Aeronautical Test Range (WATR) mission control center (MCC).
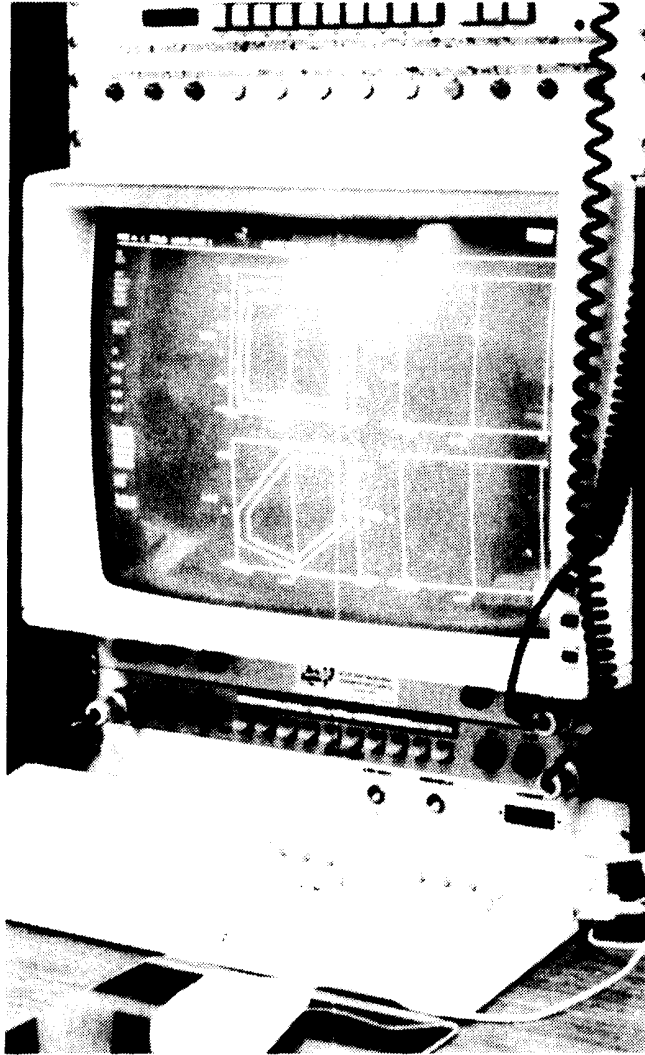
EC87-0233-002

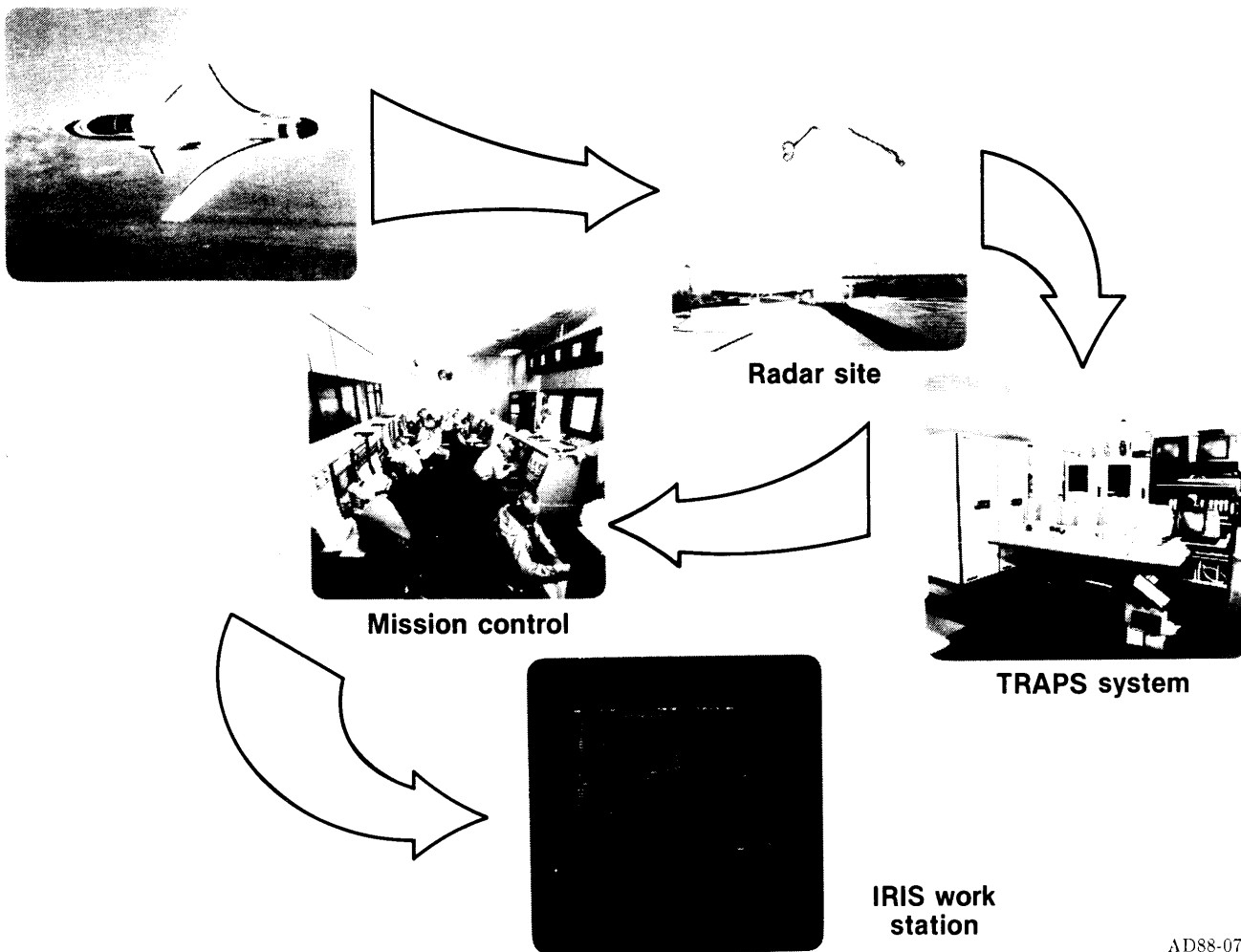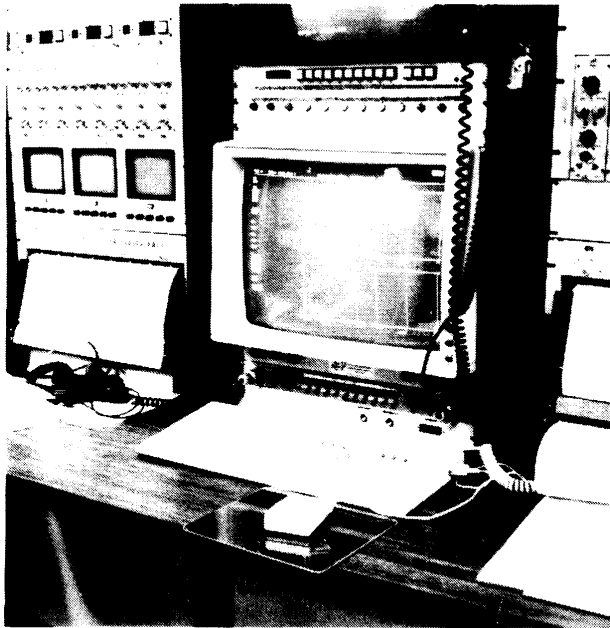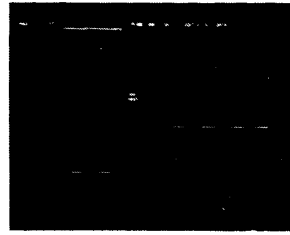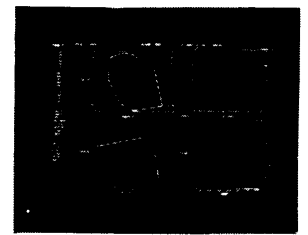*Fig. 2 Interactive raster imaging system (IRIS) workstation.*

Radar site

Mission control

TRAPS system

IRIS work station

AD88-071

Fig. 3 Master graphics interactive console (MAGIC).
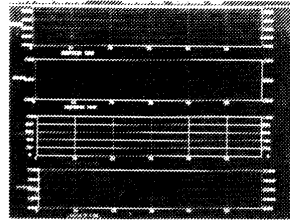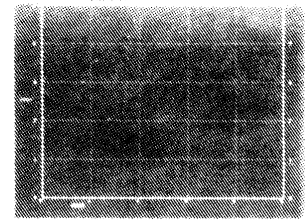
1

2

**IRIS workstation
displays**

**IRIS
workstation**

3

4

AD88-073

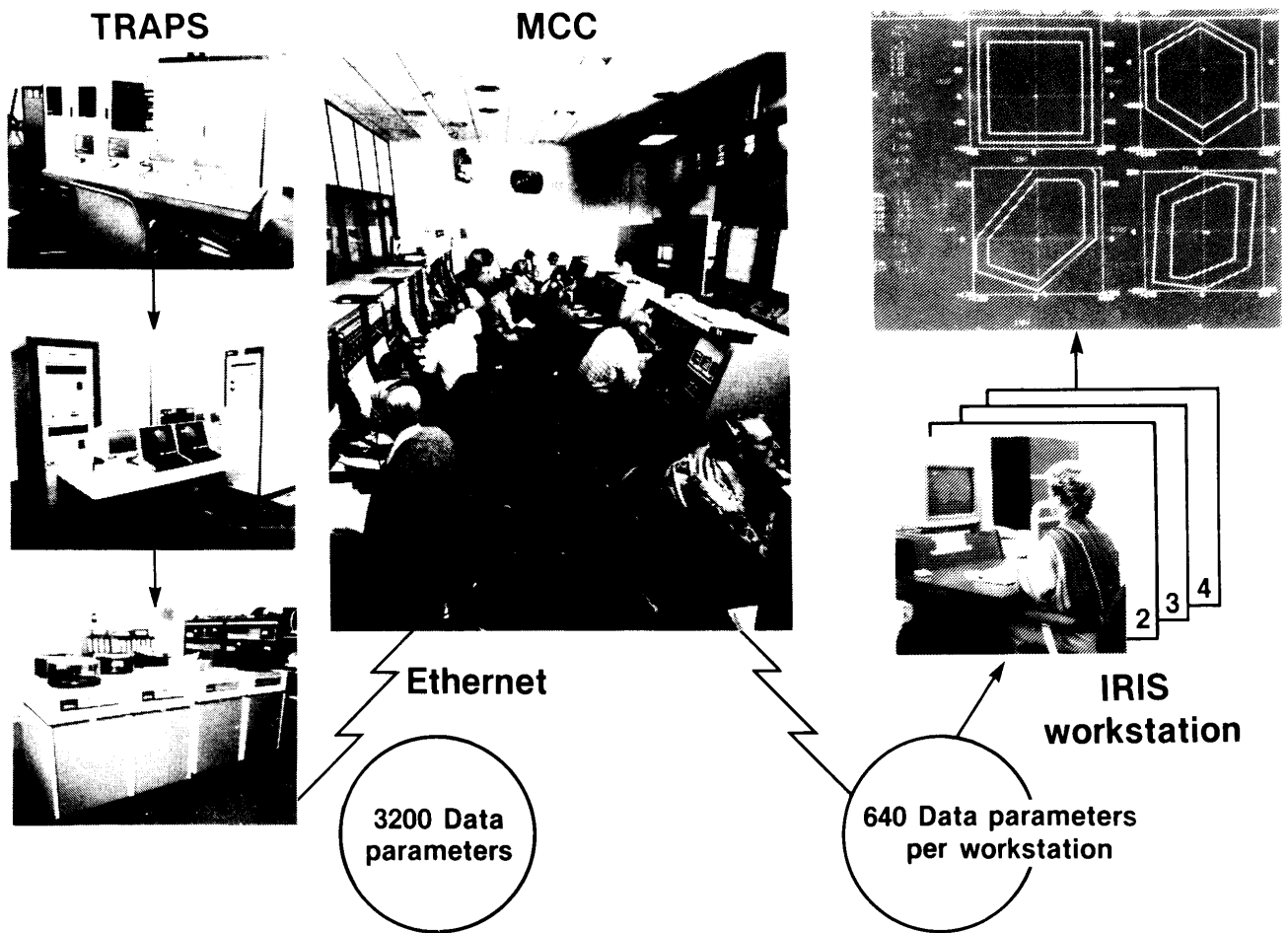*Fig. 4 MAGIC challenge: maximum data display with minimum amount of time.*

TRAPS

MCC

Ethernet

3200 Data parameters

640 Data parameters per workstation

IRIS workstation

AD88-072

Fig. 5 Hardware configuration.

(a) 10 pages per display   (b) 16 graphs per page   (c) 64 plots per page

(d) 64 parameters per page   (e) 64 digitals per page   (f) 2-25 points per polygon, 5 polygons per graph
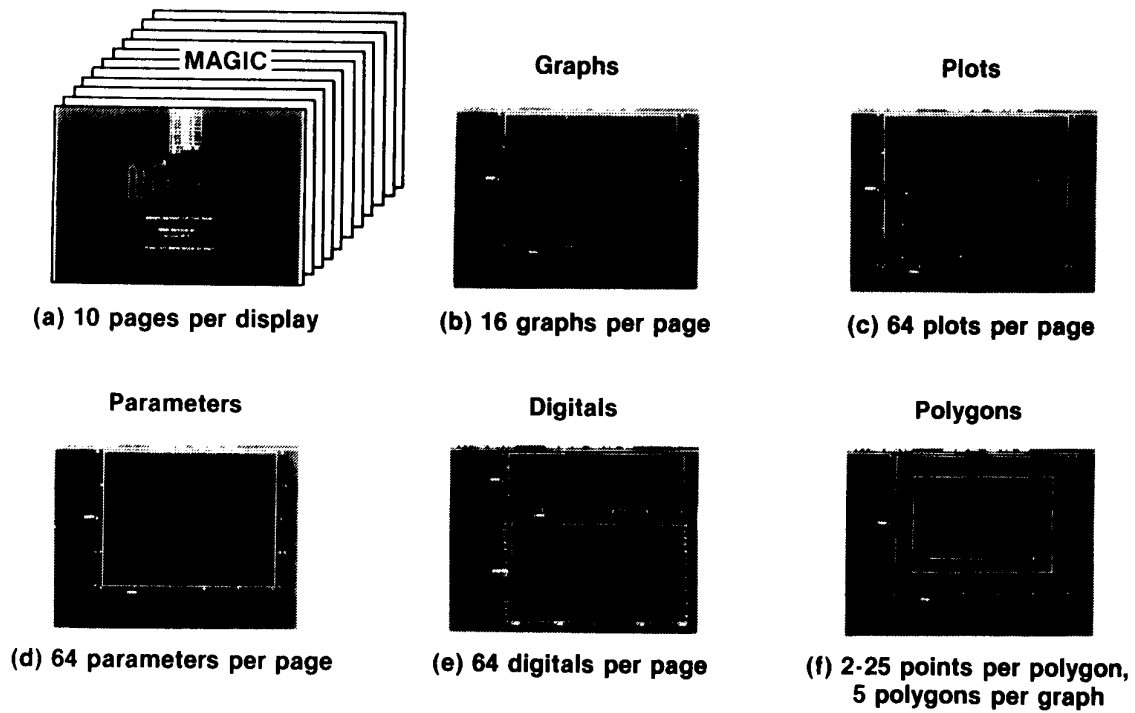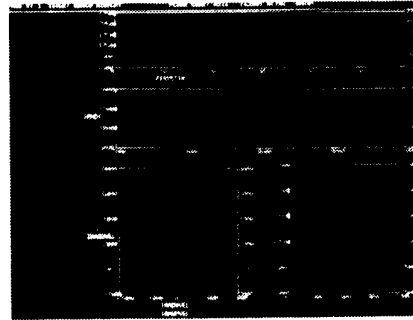
AD88-074
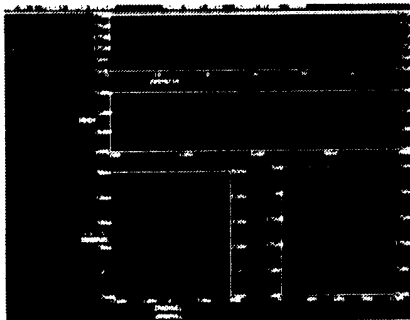
Fig. 6 MAGIC display capability.
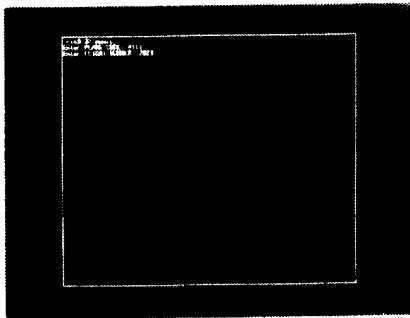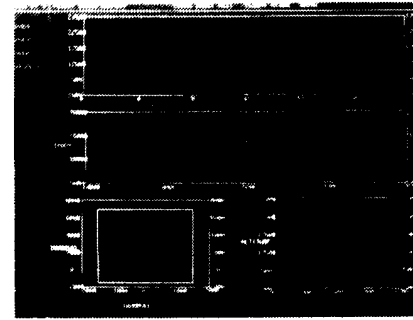
(a) MAGIC activation

(b) Types of graphs

Time history
X-Y plot
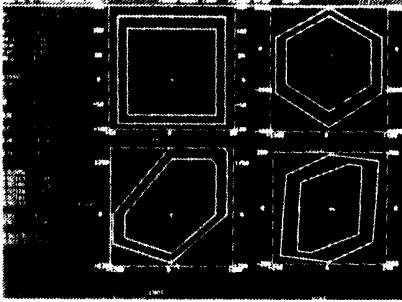**2X-2Y plot**
X-Y plot

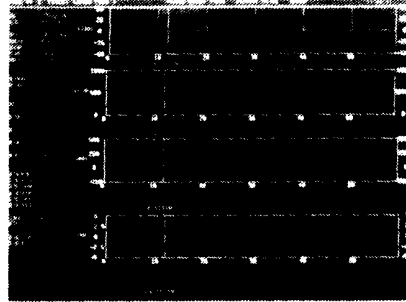(c) Graphs/digitals

(d) Polygons

AD88-075

Fig. 7 MAGIC display setup.
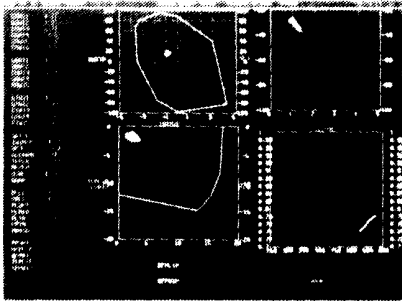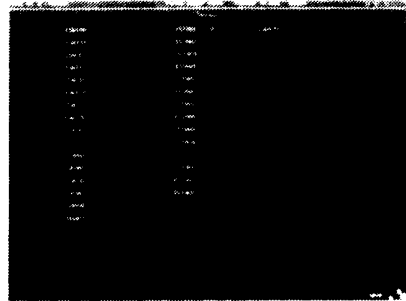
X-29 FSW1

(a) 4 plots with polygons

(b) 4 time histories

AFTI/F111 MAW

(c) 4 plots with polygons

(d) Digital page only

AD88-076

Fig. 8 Current MAGIC displays.

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